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Original Article

Evaluation of current status of lead toxicity among children: A hospital based cross-sectional study

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Abstract

Introduction: Lead is a highly toxic non-essential metal. Children have a wide spectrum of subclinical and clinical effects due to lead exposure and lead poisoning. **Objectives:** To identify the extent of the problem of lead toxicity among children and its association with anthropometry, nutritional status and awareness about lead toxicity. **Materials and Methods:** Study population comprised children admitted in CSI Hospital as inpatients. Purposive sampling was done to enroll patients with no risk of lead exposure. A sample size of 100 was calculated using prevalence formula. Anthropometric and blood examinations were done along with knowledge, attitude and practices questionnaire to assess knowledge of caregivers about lead toxicity. **Results:** A total of 100 children were screened. The mean (standard deviation) blood lead level (BLL) was 7.1 (3.6). 18% of the children demonstrated BLLs of >10 µg/dl. 19.3% of boys as compared to 15.8% girls had BLL >10 µg/dl. 36.4% of children belonging to the lower socio-economic status had BLL >10 µg/dl. The developmental quotient was inversely proportional to the measured BLL. Mean weight, height, and blood indices were lower in the children with BLL >10 µg/dl. The knowledge regarding the adverse health effects of lead toxicity was very poor. **Conclusion:** Once the early toxic effects are detected before the onset of irreversible changes, the potential victims can be saved. So screening of children for lead toxicity should be made mandatory whenever doubt arises, and since knowledge regarding lead toxicity is poor among caregivers, awareness should be created through health education to the community.

Key words: *Lead, Blood indices, Blood lead levels*

Lead is a highly toxic non-essential metal. It is ubiquitous in the environment as a result of industrialization. Children have a wide spectrum of subclinical and clinical effects due to lead exposure and lead poisoning. The best studied subclinical effect is cognitive impairment. Inattention, hyperactivity, aggression, delinquency, and poor scholastic performance are other studied effects. Lead levels above 25 µg/dl interfere detectably with heme synthesis. Children with blood lead concentrations >60 µg/dl may complain of pain abdomen, nausea, and various central nervous system manifestations including convulsions [1].

The awareness of people about lead being a source of toxicity is mainly limited to petroleum products. Very few have knowledge of domestic sources of lead, such as paint, water, and soil [2]. Children and adults differ in the relative risks of sources, metabolism and the ways in which toxicities are expressed. The absorption of lead is increased in the presence of nutritional deficiencies that are more common in children than in adults, e.g. iron deficiency [3].

This study is aimed at evaluating the pattern of elevated levels of lead in children between one and 5 years belonging to Bengaluru city visiting Church of South India Hospital with no known risk factors to lead pollution. We also planned to study the awareness of parents and caregivers regarding lead poisoning in children and the possible effects of toxic levels of lead in this population.

MATERIALS AND METHODS

The study was conducted at CSI Hospital, Shivaji Nagar, and Bengaluru city between January 2011 and December 2011. The study population comprised children aged 1-5 years, belonging to and residing in Bengaluru city, who were admitted for any other purpose and whose blood sampling was being done for various medically indicated investigations. They were from a mixed socio-economic group with no known risk factors to lead exposure. Purposive sampling was done to choose the study subjects after excluding them as per the exclusion criteria. Patients fulfilling the inclusion criteria and whose parents willing to participate in the study were enrolled in the study until the required sample size is attained.

Children with known risk factors to lead exposure were excluded from the study such as children whose household family members work in lead-based industries/workplaces, or children residing in vicinity of lead-based industries/workplaces, children already screened for blood lead levels (BLLs), special children (as control over mouthing is difficult), children with history of pica or Kajal/Surma usage and residential location <500 m from highway/main road.

A sample size was estimated using in Master software. From the study conducted in Bengaluru city in 1997 [4,5], considering the expected proportion of children with BLL above 10 µg/dl to be 33%, with a relative precision of 30% and desired confidence interval of 95%, the required sample size was 87. An additional of 20% was added to ensure precision making the total number to be 100.

After taking informed written consent, the parents and caretakers were provided an open-ended questionnaire to examine Knowledge, attitude and practices related to lead exposure. Questionnaire regarding risk factors and anthropometric data were filled in predesigned proforma. Precautionary measures to avoid lead contamination such as use of powder free gloves; dust free environment and free containers to collect the blood were taken. The venous blood was collected in EDTA container. 5 µl of this sample was mixed with the reagent provided.

The BLL was measured using Lead care 11 blood lead analyzer model no 70-6529, made by ESA Biosciences. This uses anode stripping voltammetry method for measuring the blood lead concentration [6]. The instrument was provided by National Referral Centre for Lead Poisoning in India, ST John's Medical College, Bengaluru. Simultaneous hemoglobin and blood indices (mean corpuscular volume [MCV], mean corpuscular hemoglobin [MCH]) measurement was done using SYSMEX KX 21, fully automated hematology analyzer. Peripheral smear examination was done for the presence or absence of microcytic hypochromic anemia.

Anthropometric indices weight and length/height were measured using the standard procedures and the percentiles were plotted on Indian Academy of Pediatrics growth charts [7]. The developmental assessment was done using Gessel's Developmental schedule [8]. Developmental quotient (DQ) was calculated accordingly:

$$DQ = \text{Developmental age/chronological age} \times 100$$

The socio-economic status was scaled using revised Kuppuswamy socio-economic status scale [9]. The answers to the questions 1-5 were categorized as correct, partially correct and incorrect (The answers that were wrong/not answered/not known were categorized as incorrect). A score of 4, 2, and 0 was assigned. The answer to the question 6 was categorized as either yes or no (Answered as no and not answered were categorized as no). A score of 2 and 0 was assigned. Thus, the maximum attainable score was 22.

Statistical analysis

The data were entered into a computerized Excel (Microsoft Excel 2007) spreadsheet. Subsequently, it was analyzed using Statistical Package for Social Sciences Version 11, 2003. Descriptive statistics, Chi-square test for qualitative data and Student's *t*-test to compare between mean values of DQ, weight, and height/length, hemoglobin, MCV and MCH was used. Spearman's rank correlation was done to correlate the level of awareness of lead poisoning among the parents and their socio-economic status and BLL in their children.

RESULTS

A total of 100 children admitted to CSI Hospital were screened for lead toxicity with the above-mentioned tests. 18% of the study population had BLLs >10 µg/dl (and <20 µg/dl) and 66% had > 5 µg/dl. 100 children were screened (38 girls and 62 boys). The mean BLL was 7.1±3.6 µg/dl. 19.3% of boys as compared to 15.8% girls had BLL>10µg/dl. Higher percentage (27%) of children belonging to 25-60 months age group had BLL>10µg/dl. Relationship between BLL and various studied factors are shown in Table 1.

Awareness about lead toxicity was dependent on socio-economic as shown in Table 2. Upper socio-economic class had more awareness on lead toxicity compared to middle and lower which was statistically significant p<0.001.

Table 3 describes the relationship between awareness about lead toxicity and BLLs. There was no significant difference in the mean score of awareness at different BLL. Analysis of open ended questionnaire demonstrated the overall poor awareness of the parents/ caregivers regarding lead pollution and its effects in children (Table 4).

DISCUSSION

Exposure to lead from occupational and community environment, contaminated food and consumer items, and water are of major concern. Apart from these, build up of lead in the environmental compartments is still an issue of high exposure risk in India, inspite of the relatively lesser organized production and use of lead as compared to the developed countries. Efforts in the direction of detection and analysis of lead in various matrices, as a function of human exposure and earliest effects, is a priority need. Once the early toxic

Table 1: Relationship between BLLs and various associative factors

Variables	Blood levels of lead (μg/dl) N (%)				Chi-square	p value
	0-4.9	5-9.9	10-14.9	15-20		
Age groups (months)						
12-24	13	11	1	4	5.241	0.155
25-60	21	37	12	5		
Sex						
Male	21	29	7	5	3.485	0.323
Female	13	19	6	0		
Socio-economic status						
Lower	3	11	8	2	19.92	0.003*
Middle	20	30	5	3		
Upper	11	7	0	0		
Development quotient, mean (SD)	91.47 (2.063)	89.83 (2.461)	87.77 (1.691)	86.80 (2.168)	190.66	<0.001**
Weight, mean (SD)	12.25 (2.030)	12.21 (2.38)	11.43 (2.62)	11.38 (0.864)	9.718	0.594
Height (length), mean (SD)	87.69 (8.64)	90.23 (9.64)	88.0 (6.16)	89.3 (8.90)	162.22	0.572
Hb (g/dl), mean (SD)	12.2 (0.90)	10.63 (1.34)	9.58 (0.73)	9.64 (0.53)	90.42	<0.001**
12-24 months						
Hb<2 SD for age, N (%)	0	4	1	1	11.66	0.009
Hb>2 SD for age, N (%)	13	7	0	0		
24-60 months						
Hb<2 SD for age, N (%)	5	30	12	4	29.72	<0.001**
Hb>2 SD for age, N (%)	16	7	0	0		
MCV (fl), mean (SD)	81.23 (4.05)	74.52 (9.46)	70.70 (4.76)	72.12 (1.96)	1471.4	<0.001**
MCH (pg), mean (SD)	26.90 (1.78)	23.72 (3.34)	22.2 (2.57)	22.24 (1.41)	317.95	<0.001**
Peripheral smear						
Anemia present	4	30	13	5	40.788	<0.001**
Absent	30	18	0	0		

***Significant, **Highly significant. SD: Standard deviation, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, Hb: Hemoglobin**

Table 2: The correlation between the levels of awareness to the socio-economic status of the family

Socio-economic class	N	Mean rank	Chi-square	p value
Lower	24	28.67	19.825	<0.001**
Middle	58	55.57		
Upper	18	63.28		
Total	100			

****Highly significant**

Table 3: The correlation between the levels of awareness to the BLL groups

BLLs μg/dl	N	Mean rank	Chi-square	p value
0-4.9	34	59.44	9.254	0.026
5-9.9	48	49.77		
10-14.9	13	31.85		
15-20	5	45.20		
Total	100			

BLL: Blood lead level

effects are detected before the onset of irreversible changes, the potential victims can be saved.

With this aim, present study was planned to study the current situation of lead poisoning in children aged one to five years in Bangalore city and to correlate the same with socio-economic condition of the family, developmental assessment, nutritional status and anemia. 18% of the study population had blood lead levels > 10μg/dl and 66% had >5μg/, although these figures are much less than those found in a lead screening study Project Lead–Free (1999) [4,5] and the data analyzed from National Family Health Survey, in 1998-1999 [10]. Also, results of this study cannot be extrapolated to whole of the children in Bangalore city as we enrolled children with no risk factors for lead poisoning.

In our study, higher percentage (27%) of children belonging to 25-36 months age group had BLL>10μg/dl. The elevated blood levels with respect to age showed no significant variation. This is not consistent with the results from several studies where the BLL found to be highest among 2 years old

Table 4: Responses of the parents/caregivers to the questionnaire

Questions	Response N (%)		
	Correct	Partially correct	Incorrect
What is lead	22 (22)	65 (65)	13 (13)
Health risks associated with exposure to lead?	2 (2)	13 (13)	85 (85)
Information about lead related health effects?	20 (20)	38 (38)	42 (42)
What do you think of when you hear “lead poisoning”?	2 (20)	6 (6)	92 (92)
Exposed to lead and how can we reduce it?	6 (6)	12 (12)	88 (88)
	Yes (%)	No (%)	
Would you accept to have your environment tested for lead?	81 (81)	19 (19)	
Cumulative score (maximum score 22) Mean (SD)	6.29 (4.344)		

SD: Standard deviation

children [11, 12]. Hayes et al, in their analysis of more than 50,000 samples, have clearly shown that the highest incidence was found in children around 2 years [13].

There was no significant difference in the prevalence of elevated BLL based on the gender though BLL >10 μg/dl was slightly higher in boys than girls (19.3% vs. 15.8%). This is in consistence with the study by Olaiz and Rojas in the city of Mexico [14]. This strongly points to the view that both groups of children are exposed to similar risk factors, resulting in similar outcome.

Children belonging to lower socio-economic status had highest percentage of BLL>10μg/dl (36.4%). Mean BLL was also higher in them as compared to middle and upper class. Byers RK, in his report on 45 cases of lead poisoning, has clearly noted lower socioeconomic status as a risk [15,16]. Many factors could contribute towards it, like parental education, playing outside, pica, malnutrition etc.

Developmental assessment measured as DQ was inversely proportional to measured BLL. Mean weight and height were lower in children with BLL >10μg/dl; although, difference was not statistically significant. Nutritional deficiencies of essential metals have been shown to increase the hazard from lead exposure by enhancing the absorption and toxicity of dietary lead. Studies have shown that deficiencies of iron, calcium, protein and zinc are related to increase in BLL and perhaps increased vulnerability to the adverse effects of lead [17].

Hemoglobin and blood indices were lower in majority of children with higher BLL. The higher the BLL was more the chances were for child to have microcytic hypochromic anaemia. This indicated that children with higher BLL had more chances for iron deficiency anaemia. The results of Clark et al [18] and Norden et al [11], indicated that lack of iron may both exacerbate effects of excess lead and independently adversely affect intellectual function. There is evidence that higher dietary iron intake is associated with lower blood lead among urban preschool children. Iron fortification to children with higher blood levels was found to reduce lead levels in a study conducted in Bangalore [19]. Such promising studies can be undertaken.

In our study, analysis of open ended questionnaire demonstrated the overall poor awareness of the parents/caregivers regarding lead pollution and its effects in children. Though good number of them answered regarding sources of lead, the knowledge was limited to batteries and paints. Only handful of them answered regarding, soil, dust, groundwater and vehicular traffic. The knowledge regarding the health effects was very poor. The promising part was majority were willing for the environment of stay to be tested for lead if the child's lead level was found to be above the safe limits. Therefore, the parents and children should be ensured of the information and have an access to education regarding child health and environmental pollution.

The limitations in this study include small sample size, and it was not the exact reflection of the entire Bangalore city as it was among inpatients of a hospital. It requires further community based large interventional studies to generalize the results of the study. Studies for actively searching the source of lead in children can be accomplished using a field X-Ray fluorescence analyzer [20]. However, we could not use this also. Developmental assessment could have been done in a more specialized manner by developmental assessment professionals and can be serially followed in later years.

CONCLUSION

Authors express concern over 66% of children with lead levels above 5μg/dl, (i.e. the current level of concern as per Centre for Diseases Control and Prevention) as well as the poor awareness about lead poisoning. We advocate for a national programme for lead levels screening tailor made both for children at risk and with known exposure. Lead poisoning in children is preventable and with proper concerted efforts a lead-free society can be envisaged.

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